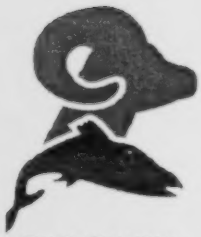

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Donna Creek Forestry/Biodiversity Project: Breeding Bird Point Counts 1995

L. W. Gyug
March 1996

PWFWCP Report No. 53

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ABSTRACT

These breeding bird surveys in 1995 were the first of 2 planned consecutive years of breeding bird surveys as part of the Donna Creek Forestry/Biodiversity Project in the ESSFmv3 240 km north of Prince George B.C. Three clearcuts, each of approximately 100 ha, were divided into 4 treatment units of each combination of presence/absence of stubs (3-m tall stumps at 8-10/ha) and tree islands (0.18-0.40 ha tree patches occupying 3.3-4.7% of clearcut area with one larger 1.4 ha island included in one cutblocks). This 2x2 randomized-block ANOVA design determined stub effects and tree island effects within clearcuts on breeding bird detection densities. Concurrent sampling within 3 adjacent old-growth forests and 3 nearby clearcuts allowed comparisons of both overall bird detection densities within experimental treatments, and bird detection densities within tree islands alone, to control forests and clearcuts. Breeding birds were sampled by 50-m fixed-radius point counts from May 22 to June 26, 1995.

Significantly greater densities of tree swallows and yellow-rumped warblers were found within clearcuts where stubs were present. Higher (but not significant) densities of black-backed woodpeckers, mountain bluebirds and pine siskins were also noticed in the clearcuts with stubs. When the overall bird densities were considered within clearcuts, tree islands had no significant effect for any species, because they appeared to occupy such small percentages of the overall area. However, when densities of only the tree islands were examined, densities of American robins, black-backed woodpeckers, chipping sparrows, Swainson's thrushes, Wilson's warblers and yellow-rumped warblers were significantly greater in the tree islands than in the clearcuts. On average, the presence of stubs in a clearcut appeared to have increased species richness by 4.0 species over a clearcut without stubs (29% increase). The presence of tree islands appeared to have increased species richness by 8.3 species over a clearcut without tree islands (61% increase). However, even with these mitigative measures, the average species richness of clearcuts with tree islands was still 7 species lower than in Old-Growth Control forests.

It appeared that small tree islands of 0.18-0.40 ha will be unsuitable for establishment of breeding territories for 13 of the 25 common forest bird species in the study area, and that larger tree islands or other mitigative measures will have to be considered for these species. However, both small tree islands and isolated stubs in clearcuts will be used by some cavity-nesting species for both nesting and foraging, and they appear to be essential for nesting of some species within clearcuts. Both techniques can be used, at least partially and for some species, to mitigate the adverse impacts from the loss of wildlife trees during clearcutting.

Recommendations are made to collect some additional data on uncommon species during the 1996 point counts, and to collect additional vegetation and physical data.

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Acknowledgements

This project was conducted under contract to the Peace/Williston Fish and Wildlife Compensation Program, Prince George, B.C. This program is a cooperative venture of B.C. Hydro and B.C. Environment supported by funding from B.C. Hydro. The program was initiated to enhance and protect fish and wildlife resources affected by the construction of the WAC Bennett Dam on the Peace River and the subsequent creation of the Williston Reservoir. Additional funding came from the Habitat Conservation Fund of B.C. Peace/Williston Fish and Wildlife Compensation Program wildlife biologist Mari Wood was the coordinator and contract monitor for the Donna Creek Project. Field work was conducted by Jeffrey Joy, Ruth van den Driessche and Michael Murphy. Fletcher Challenge Canada Ltd. (now TimberWest Forest Ltd.) provided room and board for field staff at their Munro Camp. I thank Mari Wood, Doug Heard and Jeffrey Joy for manuscript review.

1.0 INTRODUCTION

The Donna Creek Forestry/Biodiversity Project was initiated in 1990 as a cooperative venture of the Peace/Williston Fish and Wildlife Compensation Program and Fletcher Challenge Canada Ltd (now TimberWest Forest Ltd.). The aim of the project is to develop and test alternative timber-harvesting techniques designed to benefit tree-cavity-nesting birds and mammals. Animals that nest or roost in tree cavities are at some risk in the managed forest because Worker's Compensation Board regulations prohibit the maintenance of any standing diseased or dead trees taller than 3 m on worksites (Backhouse 1993). This project was designed to test whether creating 3-m high stumps (stubs) and retaining small residual tree islands during clearcutting would benefit cavity-using animals. Annual and other reports detailing the initiation and first phases of this project are available (Dawson et al. 1992, Wood 1992, Wood 1994, Wood 1995).

Preliminary breeding bird sampling began at the Donna Creek study sites in 1993 (Gyug and Summers 1995). After analysis and interpretation of this preliminary data, Gyug and Summers (1995) made recommendations to increase the efficiency and accuracy of sampling by replacing the initial transect sampling method used in 1993 with a point-count method for subsequent years. The results reported here are the first of 2 consecutive seasons (i.e., May-June of 1995, and May-June of 1996) of breeding bird sampling using the point-count methods. Cavity-nesting birds were the focus group for this study since the alternative harvesting techniques have been proposed to mitigate the effects of clearcutting on them in particular, but data was also collected and analyzed for other breeding passerines.

1.1 Objectives

The overall objective of this portion of the Donna Creek Forestry/Biodiversity Project was to determine the effect of 2 alternative timber-harvesting techniques—the retention of residual tree islands and creation of 3-m stubs during clearcutting—on the densities of breeding birds in the moist, very cold variant of the Engelmann Spruce-Subalpine Fir biogeoclimatic zone (ESSFmv3). To accomplish this, the following objectives were set for the 1995 point count sampling and data analysis:

•to determine the effects of the 2 experimental timber-harvest treatments on relative breeding bird densities within clearcuts using a 2-factor Analysis-of-Variance experimental design,

•to determine whether the clearcut treatments were representative of normal clearcuts that are not immediately adjacent to treatments with tree islands and stubs, by contrasting the clearcut treatments with clearcut controls,

•to determine the effectiveness of the alternative timber-harvesting techniques in mitigating the effects of clearcutting on forest bird species by contrasting relative breeding bird densities in the treatment areas to Old-Growth control forests,

•to determine whether breeding bird detection densities differed in tree islands compared to control clearcuts and control old-growth forests, and

•since this was also an interim report of a study-in-progress, use exploratory data analysis techniques, such as cluster analysis and power analysis, that could highlight results that could be more fully explored in the second year, or to find ways to improve study design or efficiency.

2.0 STUDY AREA

The Donna Creek study area is located at the south end of the Wolverine Range of the Omineca Mountains, approximately 80 kilometres northwest of Mackenzie and 240 km north of Prince George, British Columbia (Figure 1). Detailed location notes and geographical descriptions of the study area are available in Dawson et al. (1992). The study area is in the Manson Plateau Ecosection of the Omineca Mountains Ecoregion of the Sub-Boreal Interior Ecoprovince. The study plots are in the moist very cold variant of the Engelmann Spruce Subalpine Fir Biogeoclimatic Zone (ESSFmv3). This zone is characterized by an ericaceous shrub layer, a sparse cover of herbs, and a relatively dense moss layer. Engelmann spruce and subalpine fir are the dominant climax tree species, with lodgepole pine as a widespread seral species (Dawson et al. 1992).

3.0 METHODS

3.1 Study Design

3.1.1 Effects of Stubs and Tree Islands within Clearcuts

The study design was a randomized block two-factor ANOVA with 2 levels of each factor (i.e., a 2x2 ANOVA). The design permitted determination of the main effects of each factor on breeding bird densities and richness, as well as the interaction effects of the factors (Table 1). The first factor was the retention of stubs (high stumps cut at 3-m height by the feller buncher) within the clearcut. Levels chosen were 1)absence and 2)densities of 8-10/ha. The second factor was the retention of green tree islands within the clearcut. Levels chosen were 1)absence and 2)3-4 tree islands, approximately 1/4 ha each in size, per treatment unit. There are four possible combinations of these two factors at these two levels:

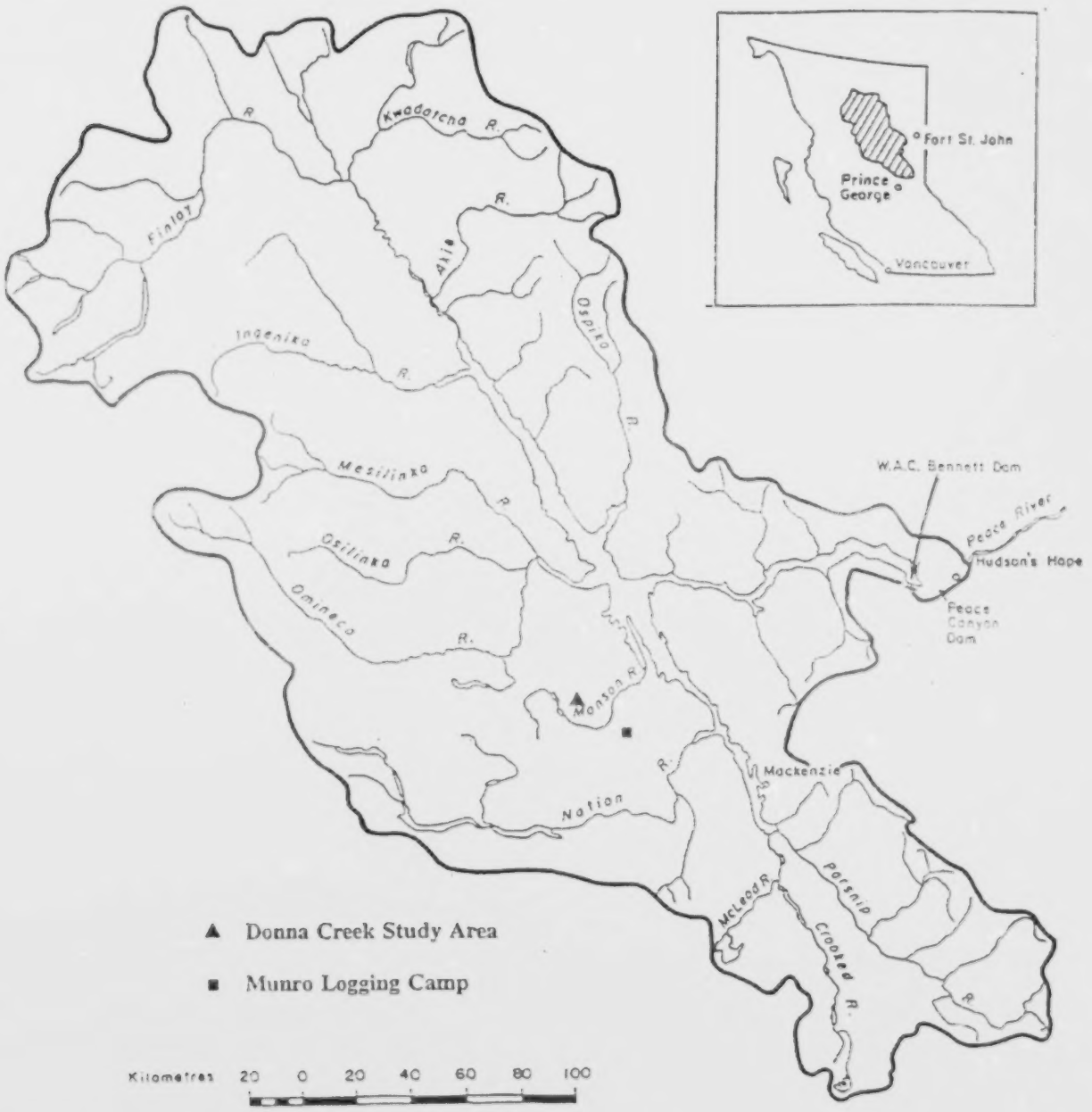

Figure 1. Location of the Donna Creek Study Area in British Columbia.

Clearcut (CC): no stubs-no tree islands,
Stub (SB): stubs but no tree islands,
Tree-Island (TI): tree islands but no stubs,
Stub-and-Island (SI): stubs and tree islands.

Table 1. 2x2 randomized-block ANOVA design used for analysis of breeding bird detection densities within experimental blocks.

Source of Variation	Degrees of Freedom
Stub Effect (S)	1
Tree Island Effect (I)	1
Interaction Effect (S*I)	1
Block Effect (B)	2
Error	6
	11 total d.f.

Each of these four treatments were applied to about one-quarter of each of the 3 experimental blocks providing for a randomized block study design with 3 replicates of each treatment. Each of the treatments is referred to hereafter by the two-letter code (CC, SB, TI, or SI) to avoid confusion between the stub and tree-island factors, and the treatments (which are each a combination of two factors).

3.1.2 Comparison of Clearcut Treatments to Clearcut Controls

To discount the possibility that "neighbour effects" of adjacent areas with stubs or tree islands were contributing to some bird use of the clearcut treatments, large clearcuts with no stubs or tree islands were selected in the study area to act as controls to the treatment clearcuts. Sampling was conducted in these clearcuts (Blocks 5510, 5549 and 5550, Figure 2) at the same intensity as in the clearcut treatments for comparison to the clearcut treatments. These blocks were termed Clearcut Controls.

3.1.3 Effectiveness of Stubs and Tree Islands as Mitigation for Old-Growth Species

Sampling was conducted in old-growth forest adjacent to each of the experimental cutblocks (5516, 5546 and 5547). This permitted comparisons of mean breeding bird use in each of the four treatments with the mean use in the old-growth forest. The choice of old-growth controls did not allow for the randomized block design since the old-growth control for Block 5546 was in the corridor of forest between blocks 5546 and 5547. There was no good basis to assign this as a control for one block in preference to the other block. A completely randomized design was therefore used for old-growth to treatment comparisons.

3.2 Description of Experimental Treatment Study Sites

Three experimental cutblocks were chosen for this study (Cutting Permit 371, Block 5516, and Cutting Permit 373, Blocks 5546 and 5547), located between 1000 and 1330 m, with the lower portions of blocks 5546 and 5547 located in the valley bottom of Soloman Creek, the main tributary to Donna Creek (Figure 2). Most of the area of the cutblocks is on moderate to strong undulating slopes (13%-24%) with a southwest exposure. The uneven topography results in a complex of soil moisture regimes including well drained slopes, wet seepage areas and ponded areas on plateaus. The characteristics of the experimental cutblocks have been previously described by Wood (1992). These descriptions are only very

Table 2. Total areas and tree-island areas of experimental Treatment Units.

Treatment Unit	Block 5516		Block 5546		Block 5547	
	Total Area ha	Island Area ha (%)	Total Area ha	Island Area ha (%)	Total Area ha	Island Area ha (%)
Clearcut (CO	34.8	0	23.7	0	24.7	0
Stubs only (SB)	31.8	0	20.0	0	32.6	0
Tree-Islands only (TI)	27.7	2.40 (8.7%)	26.5	0.88 (3.3%)	30.7	1.02 (3.3%)
Stubs-and-Islands(SD	25.5	1.11 (4.4%)	20.4	0.96 (4.7%)	23.5	1.11 (4.7%)
BLOCK TOTALS	119.8	3.51 (2.9%)	90.6	1.84 (2.0%)	111.5	2.13 (1.9%)

briefly summarized here. The exact placement of each tree island and treatment unit within each block is shown in Figure 3 with the area of each experimental unit and the total area retained as tree islands within each experimental unit summarized in Table 2.

•*Experimental Block 5516* The block is crossed by many very small runoff creeks and is the wettest of the three experimental cutblocks. Seven tree islands ranging between 0.26 and 0.40 ha in size (mean= 0.30 ha) were created in this block by reserving patches of trees from clearcutting. One additional tree island of 1.4 ha was reserved from clearcutting because of slope instability concerns. Block 5516 was logged in August/September 1992.

•*Experimental Block 5546* Six tree islands ranging between 0.22 and 0.37 ha in size (mean= 0.31 ha) were created in this block. Block 5546 was logged in October 1991 and planted with Engelmann spruce and lodgepole pine in late May, 1993.

•*Experimental Block 5547* Eight tree islands ranging between 0.18 and 0.33 ha in size (mean= 0.25 ha) were created in this block by retaining trees during clearcutting. Block 5547 was logged in October 1991 and planted with Engelmann spruce and lodgepole pine in late May, 1993.

3.3 Sampling Methods

50-m fixed-radius point counts were used to sample breeding birds. We used 50-m as the radius because we had a reasonable expectation that all birds that would sing within this radius during a 10-minute count period would be heard and counted, i.e., we could likely discount most effects of threshold detection distances for most species. Seven points were established in each treatment unit without tree islands and in each control area. Points in old-growth control areas were placed at 175-m intervals along straight transect lines parallel to, and 150 m from, the adjacent clearcut block boundaries. Points in clearcut areas were established to give relatively even coverage of the treatment units spaced at 125-m intervals. The treatment units with tree islands were stratified into 2 habitats for sampling: tree

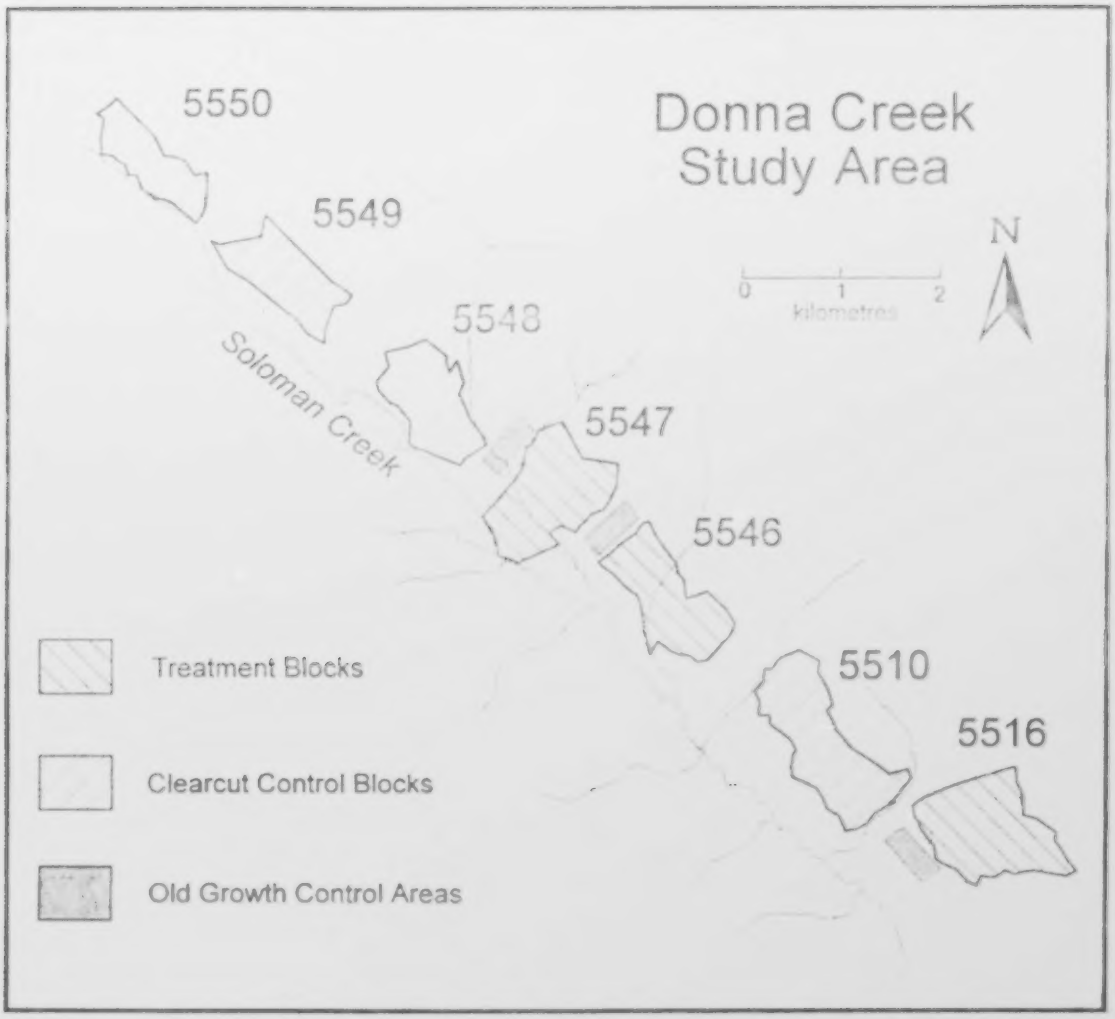

Figure 2. Location of the Experimental Treatment cutblocks, the Clearcut Control cutblocks, and the Old-Growth Control areas in the Donna Creek Study Area.

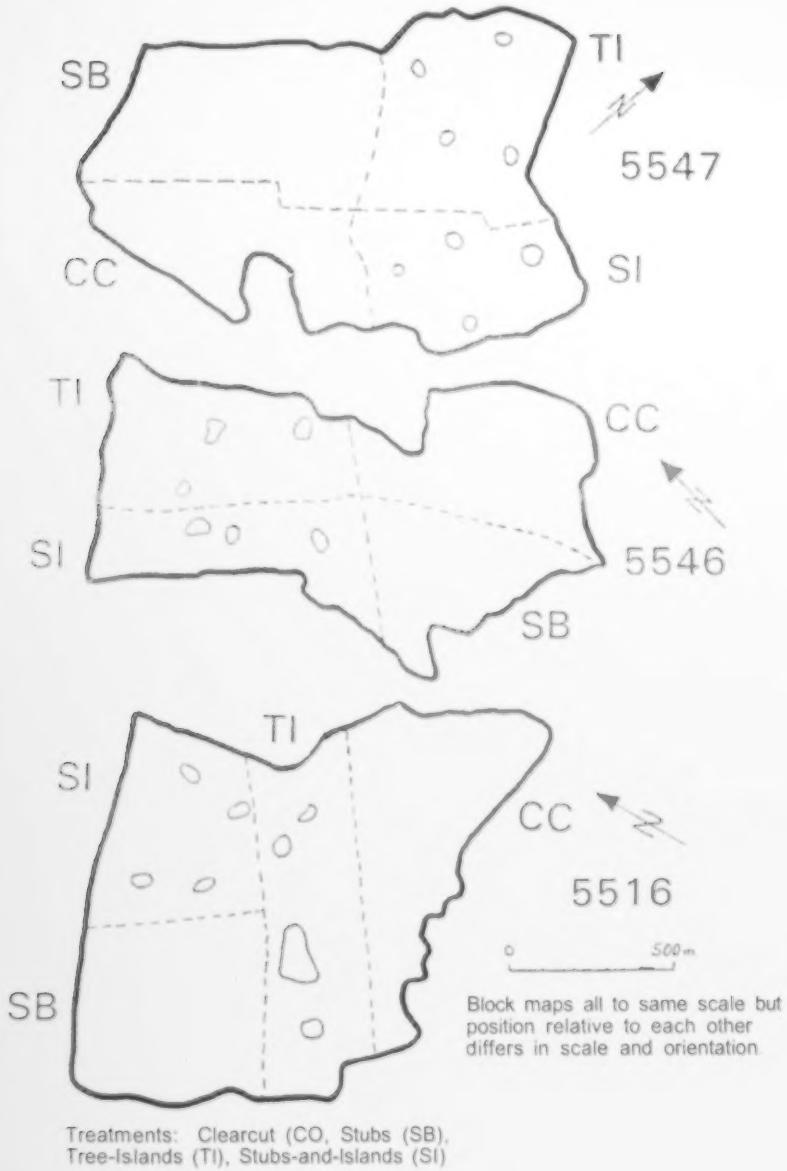

Figure 3. Location of experimental treatment units and tree islands within Blocks 5516, 5546 and 5547 in the Donna Creek Study Area.

islands, and the clearcut matrix around the tree islands. In these treatments, sampling points were established first at the approximate centre of each tree island to give total coverage of the tree islands. The only exception was the largest 1.4-ha tree island in Block 5516 where 2 points were required and coverage was still only about 80% complete. The next 7 points were placed in the clearcut matrix to give relatively even coverage and still maintain a minimum distance between points of 115 m to prevent overlap in sampling area with any of the other points. The exact locations and survey marks of each point have been described in Joy and van den Driessche (1995).

All sampling was conducted between 0415 and 1000 hrs Pacific Daylight Time. A single survey round consisted of sampling all 149 points once and took 3-4 days to complete with 3 observers. Seven survey rounds of the points were made between May 22 and June 26, 1995. Sampling at any given point was alternated between 3 observers to attempt to minimize the effects of observer bias. During a 10-minute sampling period, all birds detected within 50-m of the point were recorded. The data recorded for each bird detected included species, number, activity, and habitat feature used if the bird used a remnant tree or stub in the treatment or Clearcut Control blocks. For points within tree islands, the location of the bird inside or outside of the island was also recorded. Sampling within old-growth and tree islands began one minute after the observer had reached the sampling point to allow bird activity to adjust to the presence of the observer. Sampling at points within non-forested habitats began as soon as the observer reached the 50-m radius boundary so that any birds flushed on the approach would be included in the sampling period as suggested by Hutto et al. (1986).

3.4 Data Analysis

All analyses were done using NCSS software (Hintze 1992) except for Dunnett's Procedure which only used NCSS to provide ANOVA Mean Square Error for input to the procedure. Generalized Linear Model (GLM)-ANOVA was used throughout. Tables of means include sample standard errors for each mean, even though ANOVA models use a pooled variance technique. ANOVA is relatively robust to heterogeneity of variances when the numbers of replicates are equal (Maxwell and Delaney 1990:703), so this was not tested. With only 3 replicates per treatment or control, it was not possible to test for normality of data distribution, although we have proceeded with ANOVA that assumes normal distributions. ANOVA is also robust to all but extreme violations of the normality assumption if sample sizes are equal (Maxwell and Delaney 1990:708). All tests made were two-tailed since individual species could respond positively or negatively to any of the factors or treatments. The probability of a Type I error (a) was set at 0.05 throughout the analyses.

Effect sizes (f) of Cohen (1988) were calculated whenever numbers of replicates between treatments or controls being compared were equal. I calculated effect sizes since this was an interim report of a study-in-progress. Effect sizes and power analyses have the

potential to pinpoint how study design or sampling methods might be modified to increase the probability of the study to achieve its objectives. Cohen (1988) has suggested that an f of 0.4 should indicate a large effect size, f of 0.25 a medium effect size, and f of 0.1 a small effect size. Effect size is a continuous scale although Cohen (1988) has only indicated specific values which he has given names to. We do not have specific terms for values between, above or below these levels. For instance, we can only say that an f >0.4 is simply larger than large. The value of effect sizes will only become meaningful if they can be placed in context within an experimental design, can be used within power analysis to improve experimental efficiency, or can be related back to real-world phenomena.

Effect size is a dimensionless parameter incorporating sample size, variance and the differences between treatment means, and is one of the foundations of power analysis: f is directly related to power, all other factors being equal. The larger the f, "the greater the degree to which the phenomenon under study is manifested" (Cohen 1988:10). It therefore gives a measure beyond just "significance" or "non-significance" to gauge the strength of the phenomenon under study. However, methods do not yet exist for establishing confidence limits for f (short of independently repeating the entire experiment on different study sites) so that effect sizes cannot be statistically compared to each other. All power analyses were done using the NCSS-PASS module (Hintze 1993).

3.4.7 *Bird Detection Densities*[1]

Bird detection counts from the points had to be adjusted for area because of the stratified sampling methods used, and because the tree island points sampled unequal areas of tree island depending on the tree island size. For these tree island points, only birds detected within the tree islands were included in the calculations of density for the analyses. The sampling points and the survey rounds within a single treatment unit were not considered independent samples. Only treatments in separate cutblocks were considered independent replicates of a given treatment. Therefore the sampling points and survey rounds were only sub-samples within a treatment replicate, and were not treated separately. All calculated mean densities are the mean for an entire treatment, consisting of the average of the 3 replicates (one in each cutblock). The detection densities are expressed as birds detected per 100 ha (or 1 km^2) simply for notational convenience. For instance, a detection density of 4.3 birds/100 ha is the equivalent of 0.043 birds/ha and could also validly be expressed that way. Between species comparisons are not entirely appropriate with this data because different bird species will have different detectabilities, especially territorial songbirds compared to more silent species.

[1]The term detection densities has been used because these are relative densities based on the numbers of birds detected per unit area in 10-minute periods. These are not the equivalents of density of territories that would be calculated from spot-mapping.

Detection densities of individual species were calculated by summing all detections of a species within a single treatment replicate, and then dividing by the total area sampled within the replicate. The total area sampled was the product of the number of points, number of survey rounds, and the area sampled at each point. For replicates without tree islands, the total area sampled was 38.48 ha (7 points x 7 rounds x 0.7854 ha/point). For tree island points within a treatment replicate, detection densities were calculated by summing the birds detected in tree islands, and dividing by the product of number of rounds and the total tree-island area sampled. For treatments with tree islands, where sampling was stratified by habitat, i.e., clearcut and tree island, total detection densities were estimated using the weighted sum of the 2 strata according to the relative proportion of total area occupied by each (see Table 2).

3.4.2 Between Treatment Comparisons--Stub and Tree-Island Effects

To determine if the Clearcut (CC) treatment replicates were valid representatives of clearcuts in general, or whether there was some "neighbour effect" from tree islands and stubs adjacent to the treatments, bird densities in the CC treatments were compared to the Clearcut Controls with one-factor ANOVA. After this comparison, the 2x2 ANOVA model previously described (Sec.3.1.1) was used to determine stub and tree-island factor effects and interaction effects of the 2 factors on individual bird species detection densities. Analyses were performed for all species with at least 25 detections within the treatments.

3.4.3 Treatment to Old-Growth Control Comparisons

The Old-Growth Control units were compared to the treatments using Dunnett's Procedure (Dunnett 1955) which compares treatment means individually to the control mean. This test is more powerful for a given level of significance than other multiple-means comparisons because fewer total comparisons are made. This procedure uses a joint significance level which is set at alpha equals 0.05 for this study. Methods to calculate effect size and statistical power have not been developed for Dunnett's Procedure.

3.4.4 Tree Islands as Habitat Islands

This experiment used a subset of the data from the previous experiments so that no extra point counts needed to be done. Tree islands were treated as a separate habitat for this analysis to determine which species were found in the tree islands, i.e., were they species commonly found in control clearcuts, control old-growth forest, or was there a unique set of species that relied on tree islands as habitat.

Detection densities of common species in 3 "habitats" (Old-Growth Controls, Clearcut Controls, and the tree islands without including the surrounding clearcut matrix) were compared through one-factor ANOVA to determine which "clearcut" species and which

"forest" species made significant use of tree islands. For these comparisons, all the bird detections within tree-island points within a single block were summed and divided by the total tree-island area sampled (product of 7 rounds and total tree island area). Analyses were performed for all species with at least 12 detections within an analysis, or as few as 8 times if the species occurred in every replicate of any single treatment, control or habitat type within an analysis.

3.4.5 *Bird Communities*

Bird community macroparameters were not emphasized here because the treatments and controls were not sampled with equal effort (i.e. treatments with islands were sampled separately by habitat strata) so that species counts might be expected to be unequal simply because of the sampling strategy. However, differences in species richness (count of numbers of species detected) were examined making allowances for differences in sampling area through Analysis of Covariance (ANCOVA) when sampling areas were unequal. Clearcut Controls were compared to Clearcut (CC) treatments and comparisons made between Old-Growth Controls and treatments (not including islands) without adjusting for area since each area sampled was equal. When island habitats were included in the treatment totals, sampled area was also included in the analysis as a covariate. Species richness in tree islands were compared to the clearcut areas immediately surrounding the islands, adjusting for sampled area as a covariate.

To better describe the similarities of species composition between the treatments and old-growth controls, Simple Averaging hierarchical clustering provided graphical comparisons using singing birds only. Euclidean distance and the Jaccard Index were used to develop clustering dendrograms. Euclidean distance is sensitive to species composition and abundance as well as to dominant species (van Tongeren 1987). The Jaccard Index is based on presence/absence data so is sensitive only to species composition (van Tongeren 1987). The Jaccard Index is equal to the number of species shared by 2 treatments (or Controls) divided by the total number of species in the 2 treatments (or Controls).

4.0 RESULTS

Forty species of singing birds were detected in total (see Appendix 1). 1306 detections of singing birds of 29 species were made in the 12 experimental treatments, 685 detections of singing birds of 29 species in the 3 Old-Growth Controls, and 379 detections of singing birds of 13 species in the 3 Clearcut Controls. Fifty-nine species of birds were recorded in total on the 149 points during the 7 sampling rounds in 1995 (see Appendix 2). 3247 bird detections of 53 species were made in the 12 experimental treatment replicates, 1033 detections of 36 species in the 3 Old-Growth Controls, and 721 detections of 20 species in the 3 Clearcut Controls.

320 detections of 11 cavity-nesting species were made: the brown creeper, boreal chickadee, winter wren and boreal owl were confined to the Old-Growth areas; the mountain bluebird, tree swallow, and American kestrel were largely confined to the treatment areas; and the red-breasted nuthatch, black-backed woodpecker, three-toed woodpecker and hairy woodpecker were found in both treatment and Old-Growth Control areas. Only the boreal owl was detected too infrequently (i.e., just once) to be included in any of the analyses. It was detected first on June 14 and was present (although not detected again in point counts) until termination of field sampling on June 26 in the old-growth forest adjacent to Block 5516.

4.1 Stub and Tree-Island Treatment Effects

No bird species exhibited significant differences in mean densities between the Clearcut (CC) treatments and the Clearcut Controls (Table 3). The only likely difference which was masked by high variability may have been for tree swallows. None were detected in the CC treatments, but 14 in total were detected in the Clearcut Controls. However, the variance was such that this mean in the Clearcut Controls was not significantly different from zero.

Table 3. ANOVA statistics for the Clearcut (CC) treatments compared to the Clearcut Controls (data is in appendices for all species).

SINGING BIRD SPECIES	FM	P (a)	Effect Size	Power
American robin	0.45	.54	0.27	08
Chipping sparrow	0.06	.82	0.10	05
Dark-eyed Junco	0.00	1.00	0.00	05
Lincoln's sparrow	5.54	.08	0.96	.43
MacGillivray's warbler	2.44	.19	0.64	23
Savannah sparrow	0.35	.59	0.24	07
Wilson's warbler	0.71	.45	0.34	10
Yellow-rumpedwarbler	0.12	.74	0.14	06
All Singing Birds	4.38	.10	0.85	36
BIRD SPECIES ANALYZED USING ALL DETECTIONS				
Mountain bluebird	0.88	.40	0.38	.11
Pine siskin	0.02	.89	0.06	05
Tree swallow	6.32	.07	1.03	.48
All Birds	2.98	.16	0.70	.26

No significant interaction effects between stubs and tree islands could be shown for any of the 10 species abundant enough for analysis, or for total densities of birds (Table 4). Stubs had positive effects on detection densities of yellow-rumped warblers and tree swallows. Tree islands could not be shown within this experiment to have positive effects on the detection densities of any species. There was a significant block effect for mountain bluebirds, pine siskins, Wilson's warblers and yellow-rumped warblers with each most abundant in Block 5516.

4.2 Treatment to Old-Growth Control Comparisons

Total bird densities, using both singing detections and all detections, were significantly lower in all of the treatments compared to the Old-Growth Controls using Dunnett's test (Table 5). Thirty-two bird species were detected frequently enough to analyze for differences in means between Old-Growth Controls and treatments. Thirteen species were significantly more abundant in the Old-Growth than in all treatments: blackpoll

Table 4. Treatment detection densities of common bird species, and 2x2 ANOVA test statistics for stub and tree-island effects using randomized-block design.

Species (N Detections)	Density of Detections (Number/100 ha sampled) Block	Treatment[1] CC	SB	TI	SI	Effect	Num d.f.[2]	Test Statistics F	P	Effect Size	Power (1-β)
American robin (58 Singing)	5516	7.8	26.0	5.0	6.1	Stubs (S)	1	0.58	.47	.22	.08
	5546	0	5.2	0.5	12.0	Tree Islands (I)	1	0.30	.60	.16	.07
	5547	5.2	0	22.0	17.9	S*I Interaction	1	0.08	.79	.08	.05
						Block	2	0.60	.58		
Chipping sparrow (133 singing)	5516	20.8	18.2	28.8	16.4	Stubs (S)	1	0.55	.49	.22	.08
	5546	10.4	15.6	10.2	18.4	Tree Islands (I)	1	1.60	.25	.37	.14
	5547	7.8	10.4	11.5	29.0	S*I Interaction	1	0.10	.76	.09	.06
						Block	2	1.27	.35		
Dark-eyed Junco (185 singing)	5516	80.6	33.8	34.0	37.6	Stubs (S)	1	3.60	.11	.55	.26
	5546	31.2	15.6	37.4	36.1	Tree Islands (I)	1	0.45	.53	.19	.07
	5547	36.4	10.4	30.0	19.2	S*I Interaction	1	2.19	.19	.43	.18
						Block	2	2.92	.13		
Lincoln's sparrow (407 Singing)	5516	80.6	54.6	52.4	71.3	Stubs (S)	1	1.15	.32	.29	.11
	5546	93.5	62.4	84.0	107.2	Tree Islands (I)	1	0.57	.48	.22	.08
	5547	85.7	85.7	167.2	63.7	S*I Interaction	1	0.00	.97	.00	.05
						Block	2	1.29	.34		
Savannahsparrow (126 Singing)	5516	20.8	10.4	2.4	17.4	Stubs (S)	1	0.15	.71	.11	.06
	5546	103.9	65.0	7.5	14.9	Tree Islands (I)	1	1.18	.32	.31	.12
	5547	2.6	18.2	45.2	14.9	S*I Interaction	1	0.06	.82	.07	.05
						Block	2	1.38	.32		
Wilson's warbler (116 Singing)	5516	13.0	26.0	28.8	9.8	Stubs (S)	1	0.51	.50	.21	.08
	5546	0	0	6.8	3.5	Tree Islands (I)	1	0.06	.81	.07	.05
	5547	2.6	23.4	9.5	13.4	S*I Interaction	1	5.02	.07	.65	.34
						Block	2	6.34	.03		
Yellow-rumped warbler (101 Singing)	5516	10.4	13.0	17.4	13.9	Stubs (S)	1	10.57	.02	.94	.60
	5546	0	5.2	2.2	11.6	Tree Islands (I)	1	2.85	.14	.49	.22
	5547	2.6	13.0	5.3	5.3	S*I Interaction	1	0.04	.85	.06	.05
						Block	2	7.73	.02		
All Singing Birds (1306)	5516	257	244	198	209	Stubs (S)	1	0.23	.65	.14	.06
	5546	244	179	158	215	Tree Islands (I)	1	0.01	.93	.03	.05
	5547	145	177	300	185	S*I Interaction	1	0.00	.99	.00	.05
						Block	2	0.29	.76		
Mountain bluebird <66)	5516	31.2	31.2	10.0	47.0	Stubs (S)	1	2.41	.17	.45	.19
	5546	0	26.0	0	0.7	Tree Islands (I)	1	0.72	.43	.25	.09
	5547	2.6	0	0	0	S*I Interaction	1	0.14	.72	.11	.06
						Block	2	7.27	.02		
Pine siskin (383)	5516	83.2	119.5	88.4	103.8	Stubs (S)	1	4.61	.08	.62	.32
	5546	36.4	72.8	37.9	63.3	Tree Islands (I)	1	0.16	.70	.12	.06
	5547	2.6	28.6	35.0	44.3	S*I Interaction	1	0.00	.99	.00	.05
						Block	2	7.27	.02		
Black-backed woodpecker (56)	5516	2.6	15.6	13.5	6.1	Stubs (S)	1	2.22	.19	.43	.18
	5546	0	5.2	4.1	8.8	Tree Islands (I)	1	2.01	.21	.41	.17
	5547	0	0	2.5	12.2	S*I Interaction	1	0.44	.53	.19	.07
						Block	2	1.63	.27		
Tree swallow (29)	5516	0	13.0	4.8	9.9	Stubs (S)	1	10.93	.02	.95	.61
	5546	0	20.8	1.1	9.9	Tree Islands (I)	1	0.46	.52	.20	.08
	5547	0	5.2	3.0	0	S*I Interaction	1	3.41	.11	.53	.24
						Block	2	2.09	.21		
All Birds Detected (3247)	5516	605	738	584	640	Stubs (S)	1	0.27	.62	.15	.07
	5546	483	543	453	493	Tree Islands (I)	1	0.12	.74	.10	.06
	5547	420	408	627	503	S*I Interaction	1	0.51	.50	.21	.08
						Block	2	4.28	.07		

[1]CC = Clearcut, SB = Stubs only, TI = Tree islands only, SI = Stubs and Tree Islands
[2]6 denominator degrees of freedom in every F test.

Table 5. Significance of Old-Growth Control to treatment comparisons of mean bird detection densities using Dunnett's test.

	N Detections	Difference in Treatment Mean Detection Density relative to Old Growth[1]				Test Statistics[2]	
		CC	SB	TI	SI	MSE	d
SINGING BIRD SPECIES							
American robin	70	o	o	o	o	90.16	22.4
Blackpoll warbler	62			-		12.60	5.4
Chipping sparrow	147	o	o	o	o	43.75	15.6
Dark-eyed junco	246	o	o	o	o	201.07	33.5
Golden crowned kinglet	59					34.62	13.9
Golden-crowned sparrow	18	o	o	o	o	77.92	20.8
Hammond's flycatcher	10					8.55	8.9
Lincoln's sparrow	456	+	o	+	+	872.81	69.7
MacGillivray's warbler	39		o	o	o	9.55	10.3
Ruby crowned kinglet	51					16.92	9.4
Savannah sparrow	147	o	+	+	o	367.84	69.5
Swainson's thrush	62			-		45.37	15.9
Townsend's warbler	154					153.23	42.7
Varied thrush	18	o	o	o	o	50.06	16.7
Western wood pewee	14	o	o	o	o	6.00	5.8
Wilson's warbler	159		o	o		121.91	27.1
Winter wren	20	o	o	o	o	77.37	20.2
Yellow rumped warbler	179					167.03	30.6
All Singing Birds	2087					3041.1	130.1
BIRD SPECIES ANALYZED USING ALL DETECTIONS							
American kestrel	13	o	o	o	o	7.55	6.5
Black-backed woodpecker	58	o	o	o	o	22.48	11.2
Boreal chickadee	8					5.85	5.7
Brown creeper	11					3.15	4.2
Evening grosbeak	30	o	o	o	o	34.55	13.9
Gray jay	36			-		23.86	11.5
Hairy woodpecker	12	o	o	o	o	9.42	7.2
Mountain bluebird	66	o	o	o	o	266.94	38.6
Pine grosbeak	23	o	o	o	o	11.78	8.1
Pine siskin	515	o	o	o	o	1072.88	77.3
Red breasted nuthatch	58			-		5.62	5.6
Spruce grouse	15					9.45	7.3
Tree swallow	32	o	+	o	o	19.85	10.5
Three toed woodpecker	23					17.29	9.8
All Birds	4486					11098.9	248.6

[1] Mean densities for most species can be found in Tables 4 and 6. Data for other species in Appendix 1.
- indicates mean density is significantly lower than Old-Growth Control,
o indicates mean density not significantly different from Old-Growth Control,
+ indicates mean density is significantly greater than Old-Growth Control.

[2] MSE is Mean Square Error of one-way ANOVA with 5 levels each with 3 replicates (10 d.f.);
d is Dunnett's critical difference level expressed in densities for direct use in the table.

warbler, golden-crowned kinglet, Hammond's flycatcher, ruby-crowned kinglet, Swainson's thrush, Townsend's warbler, yellow-rumped warbler, boreal chickadee, brown creeper, gray jay, red-breasted nuthatch, spruce grouse, and three-toed woodpecker. Some of these species did make significant use of tree islands (see section 4.3) but the overall effect of tree islands on densities within clearcuts appeared to be very minor (because they made up such a small percentage of the treatment areas) and this appeared to lower the power of Dunnett's test to detect significant differences. Wilson's warbler was significantly less abundant in Clearcut (CC) and Stubs and Tree Islands (SI) treatments than in Old-Growth Controls. Only tree swallows and Lincoln's sparrows were significantly more abundant in some of the treatments than in the Old-Growth Controls.

4.3 Tree Islands as Habitat Islands

Thirty-one species of birds were detected frequently enough to analyze their densities in tree islands relative to Clearcut and Old-Growth Controls (Table 6). Only 2 species (Lincoln's sparrow and savannah sparrow) were detected significantly more frequently in clearcuts than in tree islands or in old growth. Eight species (blackpoll warbler, golden-crowned kinglet, Hammond's flycatcher, Townsend's warbler, boreal chickadee, brown creeper, evening grosbeak and gray jay) were detected significantly more frequently in old growth than in either tree islands or clearcuts. Five species (American robin, chipping sparrow, Wilson's warbler, yellow-rumped warbler and black-backed woodpecker) were detected significantly more frequently in tree islands than in old growth or clearcuts. Only one species, Swainson's thrush, was detected significantly more frequently in forest habitats, i.e. both old-growth and tree islands, than in clearcut habitats.

I further examined some of the results that did not appear to make statistical sense compared to the biological reality—in particular for those species which were absent from one or the other of the controls, but for which no significant difference could be shown between the controls in this contrast (Table 6). For 5 of the 8 species, this may simply be a factor of the low numbers counted (< 25) so that there would not be much confidence that their densities were adequately described, or that their densities were varying according to factors within old-growth or control habitats that were not measured here. This included the varied thrush, western Wood-pewee, winter wren, mountain bluebird, spruce grouse and three-toed woodpecker. The correct interpretation of these non-significant findings in these cases is that the variance was high enough that the means were not significantly different from zero. This might be remedied in the future by additional sampling, or by describing habitat variables that might be affecting these species and breaking down the samples more finely rather than at the very coarse habitat scale we examined here.

However, 2 species, the ruby-crowned kinglet and red-breasted nuthatch, were fairly abundant, occurring throughout the old-growth control areas, but were only found within the experimental treatment areas in Block 5516. Block 5516 contained the single large tree

Table 6. Comparison of densities of common breeding bird species in Clearcut Control, Old-Growth Control and Tree Island habitats.

Species	N Detections	Mean Density of Detections ± S.E. (/100 sampled ha) Clearcut Control		Tree Islands		Old-Growth Control		ANOVA Statistics $F_{2,5}$	P (α)	Effect Size	Power (1-β)
		Mean	S.E.	Mean	S.E.	Mean	S.E.				
Bird Species Analyzed Using Singing Detections											
American robin	41	8.7	6.1	30.7	9.8	6.6	6.6	3.22	.03	1.16	.86
Blackpoll warbler	62	0[a]		0[a]		63.7[b]	4.6	132.29	.00	5.52	1.00
Chipping sparrow	102	16.5[a]	13.9	135[b]	28.0	11.9[a]	0.9	14.57	.01	1.80	.96
Dark-eyed junco	122	49.4	8.1	51.0	2.2	33.8	6.4	2.31	.19	0.73	.31
Golden-crowned kinglet	58	0[a]		0[a]		60.2[b]	7.6	64.25	.00	3.13	1.00
Hammond's flycatcher	10	0[a]		0[a]		9.5[b]	3.8	5.70	.05	1.09	.66
Lincoln's sparrow	106	12.5[a]	12.3	25.6[a]	7.9	0[b]		38.34	.00	2.43	1.00
MacGillivray's warbler	44	13.9	5.7	35.3	21.3	6.1	3.8	2.58	.16	0.79	.34
Ruby-crowned kinglet	61	0		19.1	16.1	30.0	3.6	3.12	.29	0.90	.49
Savannah sparrow	75	65.0	21.6	0[a]		0[b]		9.00	.02	1.43	.83
Swainson's thrush	51	0[a]		21.9[a]	7.1	13.9[a]	5.7	11.21	.01	1.52	.93
Townsend's warbler	111	0[a]		4.5[a]	4.5	100.8[b]	17.5	29.26	.03	4.31	1.00
Varied thrush	18	0		3.4	4.1	15.0	3.1	1.98	.18	0.53	.18
Warbling vireo	12	5.2	5.2	9.3	1.0	2.8	0.0	0.39	.70	0.29	.09
Wilson's warbler	146	21.7	19.1	160[a]	44.8	37.2[a]	9.2	7.01	.03	1.25	.73
Winter wren	20	0		0		17.9	11.1	2.45	.17	0.74	.32
Western wood-pewee	10	0		15.4	12.1	2.9	2.9	1.11	.34	0.51	.19
Yellow-rumped warbler	101	8.1[a]	3.8	156[b]	36.0	67.9[b]	15.2	5.41	.02	1.17	.81
All Singing Birds	1469	328	41	760	161	494	38	4.79	.09	1.03	.56
Bird Species Analyzed using All Detections											
Black-backed woodpecker	35	0[a]		67.6[b]	14.4	1.7[a]	0.9	21.59	.00	2.19	.99
Boreal chickadee	8	0[a]		0[a]		6.9[b]	2.1	4.32	.05	1.00	.58
Brown creeper	11	0[a]		0[a]		9.6[b]	2.2	13.29	.00	1.56	.90
Evening grosbeak	13	0[a]		0[a]		11.5[b]	2.1	15.00	.01	1.70	.94
Gray jay	35	0[a]		0[a]		30.2[b]	6.2	23.56	.00	2.29	.98
Hairy woodpecker	12	0.9	0.9	15.7	15.7	3.5	3.5	0.73	.52	0.40	.17
Mountain bluebird	12	1.7	1.7	15.8	12.1	0[a]		1.50	.30	0.58	.21
Pine grosbeak	19	0		14.7	8.9	4.7	3.8	1.76	.25	0.63	.24
Pine siskin	272	53.7	11.1	191.8	56.2	89.2	17.9	4.28	.07	0.86	.52
Red-breasted nuthatch	56	0[a]		33.7[b]	33.7	30.3[b]	0.9	0.91	.45	0.40	.14
Spruce grouse	13	0[a]		3.7[a]	2.0	9.5[b]	3.8	3.82	.09	0.92	.47
Tree swallow	19	12.1	4.8	7.4	4.5	1.7	0.9	1.84	.24	0.64	.25
Three-toed woodpecker	23	0		19.6	7.5	11.3	5.3	3.46	.10	0.88	.43
All Birds	2632	625[a]	45	1689[b]	249	895[c]	37	14.01	.01	1.76	.95

[1] where the F-test is significant, i.e. $P \leq .05$, the means followed by like superscripts are not significantly different.

island in the study, and the tree islands occupied a larger percentage of the block area than in the other blocks. Within Block 5516, these species were found in the large 1.4-ha tree island and in 5 of the 7 smaller tree islands. When I removed the tree islands from the contrast, both species were significantly more abundant in the old-growth controls than in the clearcuts (where they were absent). The effect of these 2 species being absent in the experimental treatment areas of Blocks 5546 and 5547 was to statistically obscure the real effects that were present because of a large increase in variance.

For the 13 species for which no significant habitat effect could be shown, only the dark-eyed Junco appeared to be a true habitat generalist that was found at relatively equal densities in all habitats. Four species (western Wood-pewee, hairy woodpecker, mountain bluebird, and pine siskin) tended to be associated with tree islands; 4 species (varied thrush, pine grosbeak, spruce grouse and three-toed woodpecker) tended to be associated with forest habitat in both tree islands and old growth forest; the winter wren tended to be associated only with old-growth forest; and 3 species (MacGillivray's warbler, warbling vireo and tree swallow) tended to be associated with both clearcuts and tree islands. These last 3 species also appeared to be strongly influenced by other factors. For the tree swallow, that other factor might have been the presence of stubs and nests. For MacGillivray's warbler and warbling vireo, the habitat elements were probably deciduous trees and tall shrubs that were not directly either controlled or measured within this experiment.

4.4 Bird Communities

The Clearcut Controls did not contain more species than the Clearcut (CC) treatments (Table 7). When the island point counts were not included in the species totals, no significant differences could be shown between any of the treatments although the Old-Growth Controls had more species than any of the treatments. When the tree island points were factored into the species counts per treatment, the Old-Growth Controls still had significantly more species, but the treatments with tree islands (TI and SI) had significantly more species than the Clearcut (CC) treatment, with the Stubs only (SB) treatment being intermediate and not significantly different from either. On average, adding stubs to a clearcut added 4 additional species to the count, and adding tree islands added an additional 4.5 species. The presence of stubs in a clearcut increased species richness by 4.0 species over a clearcut without stubs (29% increase), and the presence of tree islands increased species richness by 8.3 species over a clearcut without tree islands (61% increase). The effects of stubs and tree islands were not additive on species richness with just as many species present in the Stubs-and-Tree Island (SI) treatments as in the Tree-Islands only (TI) treatments. However, even these tree-island enriched species totals were still 7 species lower than Old-Growth Control forests.

Block 5516 had consistently higher species richness than the other 2 experimental blocks in all of the experimental treatments and in the Old-Growth Control (Table 7). There

Table 7. Species richness of the experimental treatments, and Old-Growth and Clearcut Controls, and ANOVA test statistics.

	Species Richness (Number Species Detected)									
	Treatments[1]							Controls		
	CC	SB	TI			SI			Old Growth	Clearcut
Block			Outside Islands	Tree Islands	Total Area	Outside Islands	Tree Islands	Total Area		Block
5516	17	26	17	20	28	20	23	30	32	5510
5546	11	15	12	14	17	15	13	19	27	5549
5547	13	12	15	18	21	13	16	18	29	5550
Mean	13.7	17.7	16.0	17.3	22.0	14.7	17.3	22.3	29.3	

ANOVA TEST STATISTICS	Effect Tested	d.f. num, denom	F	P
CC treatment to Clearcut Control	Control to Treatment effect	1,4	0.10	0.77
OG and Treatments outside islands	Treatment Old Growth factor	4,8	19.43	0.00
	OG = CC, SB, TI, SI	2,8	10.26	0.01
	Block factor			
OG and Treatments including Islands	Sampled Area (as covariate)	1,7	0.09	0.77
	Treatment Old Growth factor[2]	4,7	13.12	0.00
	OG[a], SI[a], TI[a], SB[b], CC[b]	2,7	11.37	0.01
	Block factor			
Island to Non Island habitat within treatments containing islands	Sampled Area (as covariate)	1,5	0.24	0.64
	Island factor	1,5	0.25	0.98
	Block factor	2,5	8.89	0.02

[1] CC = Clearcut, SB = Stubs only, TI = Tree islands only, SI = Stubs and Tree Islands
[2] means followed by like superscripts not significantly different

were between 5 and 11 additional species counted in Block 5516 in any given treatment, and 3-5 more in the Old-Growth Control.

Cluster analysis using all birds detected indicated that the bird communities of the Old-Growth Controls were very dissimilar to the treatment units. When dendrograms were based on detection densities, two very distinct clusters formed (Figure 4A). The Old-Growth controls were more similar to each other than to any of the treatment units. Clustering patterns for the other treatment units were along block rather than treatment lines. The treatment units of Block 5516 were clustered together and the treatment units of Block 5546 and 5547 were together. The single exception was treatment unit SI of Block 5547 which clustered with Block 5516.

Cluster analysis using only presence/absence data (Figure 4B) showed the same overall pattern as with the density data. The Old-Growth Controls clustered most closely together and the treatments of Block 5516 clustered together. The Old-Growth Controls were more similar to each other than any other pairs of treatments were to each other. Among the remaining treatments, the tree-island treatments (TI and SI) of the blocks with

Figure 4. Simple Average cluster analysis dendrograms using (A) Euclidean Distance on bird species detection densities, and (B)the Jaccard Index on bird species presence/absence data. OG = Old-Growth Control, CC = Clearcut Treatment, SB = Stubs only Treatment, TI = Tree Islands only Treatment, and SI = Stubs-and-Islands Treatment.

small tree islands (5546 and 5547) clustered together, and 3 of the remaining treatments without tree islands clustered together. The single exception was the Stubs only (SB) treatment of Block 5546 which clustered with the units of Block 5516.

5.0 DISCUSSION

Both stubs and tree islands were significant factors affecting densities of some species of breeding birds within clearcut areas. The general effect was to raise "diversity" by providing additional habitat elements that could be used by some species that would otherwise be lacking within clearcuts. I will consider here first, the power of the study designs to show the effects of stubs and/or tree islands on bird species, second, the actual effects of stubs and tree islands on bird species and then on bird community diversity, third, some of the implications of these results for timber-harvesting techniques, and finally, assess the 1995 sampling methods.

5.1 Power of the study designs

5.1.1 2x2 ANOVA of Stub and Tree Island Effects

Estimation of effect sizes and statistical power reported in the 2x2 ANOVA tables, allowed us to determine the strength of this experimental design. Cohen (1988) has suggested the definition of a "large" effect size (f) as a value of 0.4. In this study, significant responses (i.e. when alpha ≤ 0.05) were consistently achieved only for effect sizes >0.7. I will term this level the statistically detectable effect limit within the study design, and the sampling methods we used. The change of sampling techniques from the transects of 1993 to the point counts of 1995 did not affect this effect limit (Gyug and Summers 1995). The point count sampling was therefore more efficient because the same power was achieved with lower sampling effort. The power of the 2x2 ANOVA with 3 replicates to detect large effect sizes (0.4) was only a very poor 16%. In other words, there was only a 16% chance of detecting a large effect as significant, even when it was present.

To put these effect sizes in real-world terms for breeding birds, I would estimate that effect sizes approaching 1.0 should be obvious fairly quickly to trained observers (e.g. tree swallow use of stubs in Table 4). Effect sizes closer to 0.4 may be more subtle, or masked by higher variability, and only be noticeable with repeated careful observations (e.g. black-backed woodpecker use of stubs and tree islands in Table 4). Effect sizes smaller than about 0.35 would appear to be relatively insignificant in terms of use of habitat elements, or else masked by so much variability that they are not easily delineated as effects with any noticeable biological significance.

The principal limiting factor of the power of this study to determine stub and tree island effects on breeding bird densities appears to be the low number of replicates of the treatment units. The number of replicates is fixed and cannot be easily changed although its effect must be considered. To obtain what I have found to be a reasonable statistical power of 50% for breeding bird analyses (Gyug 1996) would have required 9 cutblocks, each containing the 4 treatments. Obtaining 6 more cutblocks for this study is not immediately feasible but there is an alternative statistical method to raise power to detect large true effect sizes: alpha (the probability of a Type I error) can be raised until beta (the probability of a Type II error) equals 50%. In this experimental design with 3 replicates, alpha equals 0.27 for a power of 50%. To apply this to this study, alpha might therefore be raised to 0.27 as the level below which effects are accepted as significant. Using this criterion, the 2x2 ANOVA tables could be re-interpreted.

Revisiting the 2x2 ANOVA results (Table 4) with the criterion α=0.27, stubs could be interpreted as having positive effects on black-backed woodpeckers, mountain bluebirds and pine siskins, and negative effects on dark-eyed Juncos. Tree islands could be interpreted as having a positive effect on the densities of black-backed woodpeckers, chipping sparrows and yellow-rumped warblers—which would mirror the positive effect of tree islands for each of these species found in assessment of tree islands as habitat islands (Table 6).

Raising the number of replicate experimental cutblocks to 9 100-ha blocks for this study, would still amount to about 0.5% of the area actually harvested in B.C. in a year (based on 1990-91 statistics of 152,000 ha harvested on Crown lands in B.C., B.C. Min. Forests 1992). Consequently, any large effect (f=0.4 or more) seen in this study, multiplied hundreds of times over, may have great biological significance on a given species. Therefore, any species found to be affected at the very conservative alpha equals 0.05 level that we used deserves to be considered carefully when the effects of clearcutting are calculated, especially when considering the potential mitigative effects of stubs and tree islands.

5.7.2 Old-Growth to Treatment Contrast

Dunnett's test was found to be relatively powerful to detect differences for birds found (even at low densities) in the Old-Growth Controls and less abundant in the experimental treatments. However it was relatively weak for birds that were essentially absent from the Old-Growth Controls but common (or limited to) the experimental treatment areas. Dunnett's test could not show 4 of the 6 common species (golden-crowned sparrow, savannah sparrow, American kestrel and mountain bluebird) that were absent from the Old-Growth Controls to be statistically more common in any of the experimental treatments than in the Old-Growth Controls. Only for the Lincoln's sparrow (with 456 bird detections) and the tree swallow could this test find them to be more abundant in any of the experimental treatments. Consequently, Dunnett's test could only be relied on for species showing a negative response in density to clearcuts and/or the experimental treatments. This fairly

limits its application to this breeding bird data because it means that it can only be relied on as a one-tailed test in examining old-growth to treatment differences.

5.1.3. *Tree Islands as Habitat Islands*

The most powerful assessment of breeding bird densities in tree islands appeared to be from the analysis that examined tree islands as separate habitats. The 2x2 ANOVA study design and the old-growth to treatment contrast that both lumped the tree islands in with the surrounding matrix of clearcut area as an overall treatment mean appeared to do statistical disservice to the birds that actually did use the tree islands. When the tree islands only occupied less than 5 % of the treatment replicate area, the density of a given forest species in the tree islands would have to be 20 times higher than in old-growth forest to reach an equivalent density when averaged over the area of the clearcut around the tree islands. This was clearly not likely. However, by assessing the tree islands as a habitat unto themselves, a clearer picture emerged of which species were found establishing breeding territories within them, and whether this density was greater or less than in clearcuts or old growth forests.

The power of the tree island habitat contrast was only adequate (i.e. 50% or greater) to determine effect sizes of about 1.0 and greater. This power may seem lower than the 2x2 ANOVA study design which achieved power of 50% for effect sizes of 0.7 or greater, but not when the dilution effects of how the results were treated is considered. The data from tree islands made up 100% of the tree island habitat results analyzed here, compared to only about 5 % of the results in the 2x2 ANOVA study design which considered the overall treatment areas. The power of this tree island experiment to determine the effect of tree islands on breeding bird densities is therefore actually much higher than the 2x2 ANOVA study design.

5.2 Stub Effects

Densities of tree swallows and yellow-rumped warblers in clearcuts appeared to be significantly affected by the creation of 3-m high stumps (stubs) during clearcutting. The effects were not as strong (see Section 5.1.1) for black-backed woodpeckers, mountain bluebirds and pine siskins. Some nests were also found in the stubs (Joy and van den Driessche 1995) and significant numbers of cavity-nesters, as well as other birds, used them as perches or feeding sites (Gyug and Summers 1995). It appears that stubs will be used as intended by birds—for nesting, as foraging perches, as singing perches, and as foraging substrate. However, the net results of stub creation, with detectable positive effects for only 4 species, were fairly subtle compared to the much greater effect of tree islands. This is not to diminish the positive effects of stubs simply because they were not useful for as many species as tree islands. For tree swallows and mountain bluebirds, the positive stub effects could not be made up for by tree islands, which had no significant effects for those 2 species.

In 1993, the first year that breeding bird surveys were conducted at Donna Creek, the experimental treatment sites were clearcuts less than 1-1.5 years old. In 1993, significant stub effects could be shown for tree swallows, woodpeckers (as a group) and for olive-sided flycatchers (Gyug and Summers 1995). The effects of stubs on tree swallows was also found to be positive and significant in 1995. Olive-sided flycatchers were too uncommon in the 1995 sampling (6 detections) to analyze the data, although they were detected 21 times in total in 1993 sampling. In 1995 within the experimental treatments they were found only within the Stubs-and-Islands (SI) treatment replicates indicating that there may still be a stub effect and/or tree island effect as found in 1993. Mean detection densities were similar in 1993 and in 1995 (1.6 vs 0.6/100 ha in SI treatment; 0.7 vs 2.6/100 ha in Old-Growth controls).

Woodpeckers were analyzed as a group in 1993 because so many detections were not positively identified to species. In 1995 specific attention was paid to identifying woodpeckers so that species could be analyzed individually. However, only the black-backed woodpecker was sufficiently common to be analyzed within the treatments in 1995. In 1993, northern flickers and pileated woodpeckers were counted occasionally within surveys, but neither were detected on the point counts in 1995. Stubs did have a large effect on black-backed woodpeckers, but the strength of the effect was not significant at 0:=0.05 with only 3 replicates (see Sec 5.1.1. Seventeen of the 18 three-toed woodpecker and hairy woodpecker detections in the treatments were in tree islands, and were associated with nest locations. These species were only rarely observed in the treatments outside tree islands. It appears that, based on detection densities, the only woodpecker in the study area that makes much use of stubs was the black-backed woodpecker.

This study looked at stub use within the ESSFmv3 biogeoclimatic zone. If the results are to have any applicability outside this zone, we must examine the results of other studies to look for common patterns or trends. Some studies have concentrated on actual use of the stubs by birds (e.g. Morrison 1992) but I am presently aware of only one other study statistically examining breeding bird densities in relation to stubs. Bennett (1994) examined 4 densities of stub-retention (O, 3, 10 and 30 stubs/ha) in the Okanagan Highlands of the southern interior. He showed a stub effect for mountain bluebirds with significantly higher densities in clearcuts with stubs, than in clearcuts without stubs. At Donna Creek, we found a significant stub effect for mountain bluebirds in 1993, but the effect was not as strong (and not significant at α;=0.05) in 1995. Tree swallows were not common in the Okanagan Highlands study, so that the highly positive effect that stubs had on tree swallows in both 1993 and 1995 at Donna Creek could not be compared with the other study. The black-backed woodpecker was not present in the Okanagan study sites so that the response of this species to stubs could not be compared.

5.3 Tree Island Effects

The most significant use of small tree islands was by 5 species (American robin, black-backed woodpecker, chipping sparrow, Wilson's warbler and yellow-rumped warbler; see Table 4) that were also commonly found in the clearcut areas surrounding the small tree islands. This may be a characteristic of such small islands—they form excellent habitat for species with relatively plastic habitat requirements, but form relatively poor habitat for species that rely almost solely on forest cover as habitat (since they may be too small to contain entire breeding territories, see below). This was also found by Loman and von Schantz (1991) comparing small forest islands to larger islands over a range from 0.01-24.0 ha in an agricultural mosaic in Sweden. Diversity relative to habitat area may increase in the very small habitat islands, but the increase is made of species that rely on the surrounding fields for foraging—not from typical woodland species which are usually absent from these small islands.

Twenty-five of the 31 common bird species (see Table 4) were forest species, based on detection densities in different habitats within this study. About half (13 of 25) of these species were never, or only rarely, found in the small tree islands. For these 13 species, tree islands of 0.18-0.40 ha will simply not be large enough to provide suitable breeding habitat within a clearcut. These species included blackpoll warbler, boreal chickadee, brown creeper, evening grosbeak, gray jay, Hammond's flycatcher, red-breasted nuthatch, ruby-crowned kinglet, spruce grouse, Townsend's warbler, varied thrush, western Wood-pewee and winter wren in 1995. The white-winged crossbill and Tennessee warbler could be added to this list based on the 1993 sampling (Gyug and Summers 1995).

The small size of the tree islands may have been the single most important factor affecting the habitat suitability for these forest species. In Block 5516, where the single largest 1.4-ha tree island was located, 3 of the 13 species (red-breasted nuthatch, ruby-crowned kinglet and western Wood-pewee) used the large tree island as well as the smaller tree islands in the block. Red-breasted nuthatches in southern B.C. were observed combining several small tree patches (< 1 ha) about 200 m apart into single breeding territories (Gyug and Bennett 1995). However, any use of even the large tree island at Donna Creek by the other 10 forest species still appeared to be peripheral to breeding territories in the old-growth forests adjacent to the blocks.

Different species will require different sizes of tree islands to form suitable breeding territories. The smallest tree island that will be suitable for Townsend's warblers appeared to be 0.8 ha in southern B.C. while solitary vireos and western tanagers appeared to require at least 2.1 ha (Gyug and Bennett 1995). While solitary vireos and western tanagers were present in the Donna Creek study area, both were too uncommon to determine any effects within this study. The effect of tree island size on Townsend's warblers may be similar across a broad geographical range since none established breeding territories in any of the 21 small tree islands at Donna Creek or in the small tree islands in southern B.C. (Gyug and

Bennett 1995). Gray jays were commonly found in the 0.3-4.3 ha tree islands in southern B.C. (Gyug and Bennett 1995) but were absent from the very small tree patches in the Donna Creek study area. I do not specifically know why the pattern is not common among the study areas, but by the time of breeding bird sampling in May and June, gray jay young have already fledged and they may wander fairly widely contributing to high variability in count numbers, and perhaps habitat use. Varied thrushes were detected only twice in the 1.4-ha tree island at Donna Creek in 1995, and almost certainly did not breed in that tree island. They were also very uncommon in the 0.75-4.3 ha tree islands in southern B.C. so they probably require tree islands at the high end of this range, or larger, to establish breeding territories.

Several species probably require larger tree island sizes than any of those in either the Donna Creek study or the southern B.C. study of Gyug and Bennett (1995). Brown creepers and boreal chickadees did not use the tree islands in either study (but were found in the adjacent forests) so that larger habitat islands will have to be considered for management of these species. Brown creepers apparently require territory sizes larger than the tree islands examined. Brown creepers had breeding territory sizes of 2.3-6.4 ha in Michigan (Davis 1978), and the very similar treecreeper *(Certhia familiaris)* was absent from forest patches of less than 10 ha in Sweden (Loman and von Schantz 1991). Clearly, on the short-term within clearcuts, small tree islands will not serve these species.

The Donna Creek breeding bird surveys were directed at diurnal passerines and so did not sample breeding owls well. However, a boreal owl was detected on Old-Growth Control plots in 1995 although boreal owls were never detected in the tree islands, either in the plot samples or in incidental observations. Where surveys specifically targeted owls, boreal owls, as well as northern saw-whet owls and barred owls, were not detected in tree islands, but were present in the nearby forest (Gyug and Bennett 1995).

There did appear to be some effect of site tenacity, i.e. the tendency of individual birds to maintain territories even after major disturbances have rendered the habitat unsuitable for breeding. At Donna Creek in 1993, 1-1.5 years after clearcutting, some use of small tree islands and the surrounding areas by blackpoll warblers, red-breasted nuthatches, ruby-crowned kinglets and Townsend's warblers persisted, despite very clear habitat preferences of these species for forests. By 1995, no use of areas outside tree islands was detected for these species. No use of any tree islands was found for blackpoll warblers in 1995, and only 2 of 159 detections of Townsend's warblers were in tree islands. Only red-breasted nuthatches and ruby-crowned kinglets continued to use the largest tree island and some of the surrounding smaller tree islands in 1995.

Three-toed and hairy woodpeckers nested in some small tree islands at Donna Creek, but appeared to be foraging almost entirely in the adjacent old-growth forest rather than in other tree islands or in the clearcut habitats surrounding the tree islands. If old-growth forest had been unavailable adjacent to the experimental cutblocks, these 2 species may not have

used the tree islands for nesting. Through the next timber-harvest passes, the adjacent Old-Growth may not be available, and the forest within the clearcut may not have regenerated to the point where it again has become suitable breeding habitat. In the southern interior of B.C., regenerating managed forest even 25 years after clearcutting is still very poor woodpecker habitat (Gyug and Bennett 1995). If the intent of these tree islands is to provide long-term nesting habitat for woodpeckers, then timber-harvesting techniques need to be developed that allow for these species to establish stable populations that are not dependent on adjacent old-growth habitat to sustain them. Small tree islands may serve as suitable nesting sites but appear unable to meet foraging requirements of hairy and three-toed woodpeckers.

5.4 Bird Communities

The effect of both stubs and tree islands was to increase the number of species present compared to a clearcut. Species richness was higher in the TI and SI treatments because of the presence of tree islands—when the tree island points were excluded from the results, species richness in these treatments was not different from species richness in clearcuts. However, this result is not entirely unexpected since any creation of patchiness in an otherwise uniform habitat should increase species richness (Wiens 1989:128). The overall effect of tree islands on total bird density within a treatment was insignificant when tree islands occupied only very small fractions of the clearcuts (i.e. <5%). However, even though the effect on total bird density within a clearcut may be insignificant, there is significance for a few species, and there is an increase in numbers of species using the area. Tree islands occupying about 5% of the area within a clearcut would need bird densities about 6 times higher than the average in the surrounding clearcuts to significantly increase the average density within the total cutblock area[2]. While bird detection densities were higher in tree islands than clearcuts, they were only twice as high so that the effect of tree islands on total bird densities within cutblocks was minor.

Each treatment replicate in Block 5516 had 5-8 more species than the equivalent treatment in the other blocks. The effect of the one larger tree island present in Block 5516 could not have been the entire explanation of this increase in species richness although it may have accounted for the difference for 3 species (i.e. red-breasted nuthatch, ruby-crowned kinglet and western Wood-pewee). The higher species richness also extended to the Old-Growth Control areas, so there must be more than just this tree island size effect operating. Without vegetation and physical data that can be correlated with individual points, we cannot determine just what may have been causing this. With only 3 replicates, and one that has a tree island much larger than in any other, this vegetation and physical data is crucial to interpretation of the bird data. One of the alternatives to examine these species differences

[2]Significance in this case would be indicated when the mean density in cutblocks containing tree islands would be greater than the mean density+2 standard errors of clearcuts without tree islands (see Table 4).

without this vegetation or physical data would be to add more experimental cutblocks to statistically drown out the variability associated with this one cutblock. To examine the issue of tree island size, the experiment could be widened by developing more cutblocks with a wider range of tree island sizes, or the trees of this large tree island could be simply cut down to eliminate a distinct bias in the experiment. The least costly or onerous of these alternatives is to collect physical and vegetation data.

5.5 Management Implications for Timber-Harvesting

It was not the original intent of this first year of sampling to provide any definitive interpretations regarding the effectiveness of the alternative timber harvesting techniques. However, even at this stage before the final season of data of this phase of the breeding bird surveys has been gathered, some trends should be noted. In particular, isolated stubs and tree islands of 0.18-0.40 ha were of little use to the many forest bird species at Donna Creek 4 years after clearcutting. Tree islands would have to be larger than 0.18-0.40 ha to provide habitat mitigation for a wider variety of bird species. Because of the results from Block 5516, it appears that small tree islands may be used in conjunction with larger islands to provide useful habitat for some forest species. However, even if not significant for many species, both small tree islands and isolated stubs in clearcuts will be used by some cavity-nesting species for both nesting and foraging, and they may be essential for nesting of some species within clearcuts. Both techniques can be used to, at least partially, mitigate the loss of wildlife trees during clearcutting for some species.

5.6 Assessment of 1995 Sampling Methodologies

It would appear that some generally uncommon species were not as well sampled by 100-m diameter point count plots in 1995 as by 150-m width transect plots in 1993 (see discussion for olive-sided flycatchers, sec. 5.2). This indicates the trade-off made in sampling smaller areas in a more rigorous manner, compared to sampling larger areas with their higher potential for bias. The bias on transects can be caused by factors as varied as distractions to observers because of navigational difficulties while traversing rough terrain, variations in detection densities because time-effects are not as rigidly controlled on transects, and that bird detections will drop off sharply at distances even less than 75-m from the observer for many species (e.g. Roeder et al. 1987). To counter this tendency for point counts to poorly sample uncommon species, species of special interest should be recorded at the point counts within an unlimited radius, effectively turning the fixed-radius point counts into variable-radius point counts for these species. There is a very high potential for non-independence of samples using that method because the sampling points are as little as 115 m from each other. However, if collected with due attention to possible repeat counting of individual birds, this data would allow a much better assessment of the stub and tree island effects on selected species.

6.0 RECOMMENDATIONS FOR 1996 BREEDING BIRD SAMPLING

•The point count methods used in 1995 should be repeated without change in the 1996 field season to take into account some of the effects of inevitable annual fluctuations in bird numbers. Time (year) will then become a factor entered into a repeated measures ANOVA design. For species with no significant year-to-year variation in densities and/or habitat use, this will (in effect) allow pooling of data within the repeated measures ANOVA design and may strengthen the significance of the stub or tree island effects.

•The only addition to the point count sampling is that species-of-interest should be recorded at all distances from the observer during the point counts in the experimental treatments. Since typically only 1-5 birds are recorded within a single 10-minute 50-m radius point count, collecting data on a few uncommon species further away should not distract the observer from the essential task of collecting unbiased data on birds within the 50-m radius. Data to be recorded includes the species, number, behaviour (e.g. singing, drumming, flying, perched), estimate of distance and location (if in another habitat or treatment) and the level of observer confidence in this estimate (e.g. "drumming, 100-150 m distant, could have been in tree island or clearcut"), and whether the observer feels this is the same bird that was recorded on a point sampled previously that day. Species-of-interest include those possibly showing stub and/or tree island effects but that are too uncommon to be analyzed within 50-m radius point count data. These would be: all woodpeckers, American kestrel, mountain bluebird, tree swallow, olive-sided flycatcher, western-wood pewee, Hammond's flycatcher, winter wren and Tennessee warbler.

• 1:10,000 maps showing the exact locations of all sampling points in the experimental cutblocks, with their 50-m radii included, should be produced for field use by observers to assist in distance estimation for variable radius point counts.

•Simple vegetation and physical data should be collected at each bird counting point. Data collected should be no. of stubs within 50 m, no. snags within 50 m (or smaller for tree islands) and percent vegetation cover by strata (i.e. deciduous canopy trees, sub-canopy trees, tall shrubs, low shrubs and herb layer, and coniferous canopy trees, sub-canopy trees, tall shrubs, low shrubs and herb layer) tree counts by species and size (dbh and height). Physical data should include estimation of coverage of entire plot area by different soil moisture regimes and site series. This may help explain why certain Blocks (e.g. 5516) had consistently higher species diversity than others, and could be applied to individual point data to assist in explaining some of the variability in bird densities that did not appear to be directly related to the stubs or tree islands. This additional data would also be required for publication of the data in a refereed journal after the 1996 field sampling season since other environmental factors that might affect bird densities must be considered before any stub and tree-island effects found here can be considered conclusive.

•Night-time owl censuses in early spring (March through April) (preferably with playback responses), done to at least at a reconnaissance-level, could assist in design of further studies or actually determine if the small tree islands are being used by forest owls at any time.

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APPENDICES

Appendix 1. The number of singing bird detections by species for each control and treatment replicate. The 3 figures are for Cutblocks 5516, 5546 and 5547 respectively, except for Clearcut Controls, Blocks 5510, 5549 and 5550. Where all 3 were zero, a single "O" has been substituted. For treatment units with tree islands, detections within tree islands are presented separately. Total effective sampled area in a replicate is the product of 7 visits x the actual physical area sampled (i.e. 7 points x 0.7854 ha except in tree islands).

					Tree Island (TI) Treatment		Stubs-and-Islands (SD Treatment	
	Old-Growth Control	Clearcut Control	Clearcut	Stubs	Outside Islands	Tree Islands	Outside Islands	Tree Islands
Total Effective Sampled Area (ha)								
5516	38.5	38.5	38.5	38.5	38.5	15.2	38.5	7.8
5546	38.5	38.5	38.5	38.5	38.5	6.0	38.5	6.7
5547	38.5	38.5	38.5	38.5	38.5	7.1	38.5	7.8
Species								
Alder flycatcher	0	10	0	0,0,3	0	0	0,1,0	0
American robin	7,4,0	1,8,1	3,0,2	10,2,0	1,0,8	5,1,4	2,4,6	2,3,5
Blackpoll warbler	18,24,20	0	0	0	0	0	0	0
Boreal chickadee	1,0,0	0	0	0	0	0	0	0
Boreal owl	1,0,0	0	0	0	0	0	0	0
Brown creeper	1,3,5	0	0	0	0	0	0	0
Chipping sparrow	5,4,4	1,17,1	8,4,3	7,6,4	8,3,2	19,5,14	3,6,9	16,5,11
Common snipe	0	0	0	4,0,0	0	0	0	0
Dark-eyed Junco	14,9,16	12,23,22	31,12,14	13,9,7	13,14,11	7,4,5	14,14,7	5,2,3
Evening grosbeak	0,1,0	0	0	0	0	0	0	0
Fox sparrow	0	0	0	0	0	0	0	2,0,0
Golden-crowned kinglet	24,20,14	0	0	0	0	0	1,0,0	0
Golden-crowned sparrow	0	2,0,0	1,0,0	11,0,0	2,0,0	0	4,0,0	0
Hairy woodpecker	0	0	0	0	0	0,0,1	0	0
Hammond's flycatcher	3,1,6	0	0	0	0	0	0	0
Hermit thrush	0,3,0	0	0	0	0	0	0	0
Lincoln's sparrow	0	61,38,49	31,36,33	21,24,33	22,33,66	0,2,3	28,43,25	3,1,3
MacGillivray's warbler	5,0,2	7,8,1	4,0,0	0	0,3,1	4,3,9	0,1,1	0,1,4
Mountain bluebird	0	0	3,0,0	0	0	2,0,0	0	1,0,0
Northern Waterthrush	4,0,4	0	0	0	0	0	0	0
Olive-sided flycatcher	2,0,1	0	0	0	0	0	0	2,0,1
Orange-crowned warbler	0,0,4	3,0,0	0,2,0	0	0	2,0,1	0	0
Pine grosbeak	6,2,1	0	0	0	0	3,0,0	0	2,0,0
Pine siskin	3,5,2	0,0,1	0	5,1,0	0	7,1,0	1,0,0	4,3,5
Red-breasted nuthatch	10,10,11	0	0	0	0	12,0,0	0	4,0,0
Ruby-crowned kinglet	9,15,14	0	0	0	0	10	0	3,0,0
Savannah sparrow	0	41,13,21	8,40,1	4,25,7	1,3,18	0	7,6,6	0
Solitary vireo	2,0,0	0	0	0	0	0	0	0
Spruce grouse	1,0,0	0	0	0	0	0	0	0
Swainson's thrush	20,20,10	0	0	0	0	5,0,2	0	2,1,2
Townsend's warbler	59,56,37	0	0	0	0	0,0,1	0	0,0,1
Varied thrush	12,1,2	0	0	0	0	2,0,0	0	1,0,0
Warbling vireo	1,1,1	6,0,0	0	0	0	0,0,1	0	1,1,0
Western tanager	0	0	0	0	0	0	0	2,0,0
Western Wood-pewee	0,0,3	0	0	0	0	4,0,0	1,0,0	5,0,1
White-crowned sparrow	0	0	1,0,0	4,0,0	0	2,0,0	1,1,1	0
Wilson's warbler	13,21,9	2,23,0	5,0,1	10,0,9	8,1,1	17,8,15	1,0,0	13,5,22
Winter wren	15,1,4	0	0	0	0	0	0	0
Yellow warbler	0	0	0,0,1	0	0	0	0	0
Yellow-rumped warbler	21,19,38	2,5,0	4,0,1	5,2,5	0,0,1	30,4,6	2,3,2	16,6,14

Appendix 2. The number of all bird detections by species for each control and treatment replicate. The 3 figures are for Cutblocks 5516, 5546 and 5547 respectively, except for Clearcut Controls, Blocks 5510, 5549, 5550. Where all 3 were zero, a single "0" has been substituted. For treatment units with tree islands, detections within tree islands are presented separately.

					Tree Island (TI) Treatment		Stubs-and-Islands (SI) Treatment	
	Old-Growth Control	Clearcut Control	Clearcut (CO	Stubs (SB)	Outside Islands	Tree Islands	Outside Islands	Tree Islands
Alder flycatcher	0	11,0,0	0	0,0,4	0	0	0,1,0	0
American kestrel	0	0	0,0,1	0	0,2,3	0,1,2	0,3,0	0,0,1
American pipit	0	0	0	0,3,0	0	0	0	0
American robin	19,9,3	21,16,20	18,11,12	42,30,5	24,8,23	32,15,8	30,13,18	16,9,22
Black-backed woodpecker	1,1,0	0	1,0,0	6,2,0	2,1,1	17,3,0	2,3,2	2,2,12
Blackpoll warbler	19,24,20	0	0	0	0	0	0	1,0,0
Boreal chickadee	5,1,2	0	0	0	0	0	0	0
Boreal owl	1,0,0	0	0	0	0	0	0	0
Brewer's blackbird	0	0	0	0,2,0	0	0	0	0
Brown creeper	2,4,5	0	0	0	0	0	0	0
Chipping sparrow	5,4,4	3,20,3	15,6,8	10,7,5	12,5,4	26,7,22	5,7,11	21,8,15
Common nighthawk	0	0	0	0	0,0,1	0	0	0
Common raven	0,0,1	0	0,0,1	0	0,0,1	0,0,1	0,0,2	0
Common snipe	0	3,0,0	1,0,0	9,0,0	0	1,0,0	3,0,1	0
Dark-eyed Junco	20,20,34	31,60,38	66,38,45	69,30,49	57,47,57	21,18,29	46,43,54	17,21,25
Empidonax flycatcher sp.	0	0	0	0	0	0	0	0,1,0
Evening grosbeak	5,6,2	0	2,2,0	1,8,0	2,1,0	0	0,1,0	0
Fox sparrow	0	0	0	0	0	0	0	2,0,0
Golden-crowned kinglet	30,33,27	0	0	0	0	0	1,0,0	0
Golden-crowned sparrow	0	2,0,0	1,0,0	11,0,0	2,0,0	0	7,0,0	1,0,0
Gray jay	15,13,7	0	0	1,0,0	0	0	0	0
Hairy woodpecker	4,0,0	0,1,0	0	0	0,0,1	0,0,7	0	0
Hammond's flycatcher	3,1,8	0	0,1,0	0	0	0	0	0
Hermit thrush	1,5,0	0	0	0	0	1,0,0	0	0
Lincoln's sparrow	0	93,68,82	55,55,69	27,47,54	42,70,95	0,4,8	47,65,50	5,2,5
MacGillivray's warbler	5,0,2	7,8,1	4,0,0	0	0,3,1	4,3,9	0,1,1	0,1,4
Mountain bluebird	0	0,2,0	12,0,1	12,10,0	3,0,0	5,0,0	18,0,0	4,1,0
Northern Waterthrush	4,0,4	0	0	0	0	0	0	0
Olive-sided flycatcher	2,0,1	0	0	0	0	0	0	2,0,1
Orange-crowned warbler	0,0,4	3,0,0	0,3,0	1,0,0	0	2,0,1	0	0
Pine grosbeak	6,3,1	0	1,0,0	1,0,0	1,0,0	3,0,2	1,0,0	4,0,0
Pine siskin	29,48,26	15,18,29	32,14,19	46,28,11	28,14,13	38,5,5	35,23,13	30,9,20
Red crossbill	0,1,0	0	0,0,1	1,0,1	0,2,0	0	0	0
Red-breasted nuthatch	11,12,12	0	0	0	0	14,0,0	0	9,0,0
Red-tailed hawk	0	2,0,0	0	0	0	0	0	0
Ruby-crowned kinglet	10,17,17	0	0	0	0	13,0,0	0	5,0,0
Ruffed grouse	0	0	0	1,0,0	0	0	0	0
Savannah sparrow	0	50,19,31	9,50,1	6,27,7	1,8,20	0	7,7,8	0
Say's phoebe	0	0	0	1,0,0	0	0	0	0
Sharp-shinned hawk	0	0,2,0	0	1,0,0	1,0,0	0,1,0	0	0
Solitary sandpiper	0	1,0,0	0	2,0,0	0	0	2,0,0	0
Solitary vireo	2,0,0	0	0	0	0	1,0,0	0	0
Spotted sandpiper	0	0	0	3,0,1	1,0,0	0	0	0
Spruce grouse	4,1,6	0	0	0	1,0,0	0	1,0,0	1,0,1
Steller's jay	0	0	0	0	0	0	0	0,0,1
Swainson's thrush	31,29,16	0	0	0	0	9,3,3	0	3,3,3
Three-toed woodpecker	1,8,4	0	0	0	0	0,1,5	0	4,0,0
Townsend's solitaire	0	0	0	1,0,0	0	0	0	0
Townsend's warbler	60,58,39	0	0	0	0	0,0,1	0	0,0,1
Tree swallow	1,1,0	7,6,1	0	5,8,2	2,0,1	0,2,1	4,4,0	0
Varied thrush	15,3,8	0	1,0,0	0	0	2,0,0	0	1,0,0
Warbling vireo	1,1,1	6,0,0	0	0	0	0,0,1	0	1,1,0
Western tanager	0	0	0	0	0	0	0	2,0,0
Western Wood-pewee	0,0,3	0	0	1,1,0	0	4,0,0	1,0,0	6,0,1
White-crowned sparrow	0	0	2,0,0	4,0,0	0	2,0,0	1,1,1	0
Wilson's warbler	14,22,9	2,26,0	5,1,1	10,1,10	8,1,1	19,12,26	1,1,1	16,7,27
Winter wren	15,2,5	0	0	0	0	0	0	0
Yellow warbler	0	0	0,0,1	0	0	0	0	0
Yellow-bellied flycatcher	0	0	0	0	0	0	1,0,0	0
Yellow-rumped warbler	24,24,46	2,9,0	8,4,2	10,5,8	3,0,1	37,5,8	4,5,2	22,7,20
Unidentified birds	0	1,0,1	0,1,0	2,0,0	1,1,1	0	1,0,0	0,2,0